CHAPTER 7.

Biocriteria Development and Implementation

Purpose:
To provide water resource agencies with guidance for biocriteria development and implementation.

The first phase in a biocriteria program is the development of "narrative biological criteria" (Gibson, 1992). These criteria are essentially statements of intent incorporated in state water laws to formally consider the fate and status of aquatic biological communities. As stated in that guidance, attributes of sound biological criteria include the following objectives:

1. Support the goals of the Clean Water Act to provide for the protection and propagation of fish, shellfish, and wildlife, and to restore and maintain the chemical, physical, and biological integrity of the nation's waters.

2. Protect the most natural biological community possible by emphasizing the protection of its most sensitive components.

3. Refer to specific aquatic, marine, and estuarine community characteristics that must be present for the waterbody to meet a particular designated use, for example, natural diverse systems with their respective communities or taxa indicated.

4. Include measures of community characteristics, based on sound scientific principles, that are quantifiable and written to protect and/or enhance the designated use.

5. In no case should impacts degrading existing uses or the biological integrity of the waters be authorized.

Establishing Regional Biocriteria

The first decision that a resource agency must make is to determine the set of sites or class to which a biocriterion applies. Site classification (Chapter 3) permits more refined characterization of the reference condition and therefore better resolution in detecting impairment. Any characterization of a reference condition should account for the variability in the biological data used to establish the biocriteria. Thus, the reference condition can be characterized by measures of central tendency (mean, median, trimmed mean) and by variability (standard deviation, quartiles, ranges).

Statewide characterization of reference condition can be expected to exhibit high variance; however, successive intrastate classification will partition the variance from within a large class to among several different component classes. The goal of classification is to minimize within-class variability by allocating the variability to among-class differences. When this goal is achieved, it results in less variation per class and greater resolution of the criteria.

Classification into aquatic types (regional or specific habitat types) should partition overall variance (to achieve lower variability within each class than among classes). The central tendency of each class may be expected to differ (otherwise variability would not be reduced within classes as compared to all classes combined). Investigators for Ohio EPA chose to classify by ecoregion and by aquatic life use. Thus, for each ecoregion and for each aquatic life use within that region, they can characterize a central tendency and variability for the reference condition (from their reference sites).

The more refined the classification, the more precisely the reference condition can be defined; however, an agency also needs to decide when enough classification is enough. Classification can be discrete, as in ecoregions, or continuous, as along a gradient where, for example, expected species richness is a function of stream size.

Biocriteria programs can use discrete and continuous classifications simultaneously; Ohio EPA (1987) has biocriteria that vary by stream size and drainage area within its established ecoregions. The agency's calibration procedures allow investigators to normalize the effects of stream size so that index scores, such as the IBI, can be compared among all streams of a region. For example, the ratio of fish species richness to stream size is an empirical model that accounts for overall variation in species, regardless of stream size. In evaluating whether a test site achieves its species richness potential (a possible biological criterion), one would surely like to take into account the stream size factor. It would be unfair to expect a small stream (with a limited capacity to support a species-rich fish biota) to achieve a high species richness (relative to all streams). By the same token, it would not be good stewardship to allow a large stream (with expected high species richness) to meet attainment merely because its size achieves the statewide criterion.

Designing the Actual Criterion

Having selected its classification scheme, reference sites, and metrics, the agency now has the basic material needed to design the actual criterion. What statistic should be used? A variety of choices are available for measuring central tendency and variability. Two general approaches have evolved, however, for the selection of a quantitative regional biocriterion: the first uses an aggregate or index of metric values, each of which has been assigned a percentile along the distribution of represented minimally impaired sites (Ohio and Florida); the second, a multivariate analysis of metrics or other basic biological data to develop expected thresholds or attainment (Maine).

The percentile that is established for each metric in the first approach is a threshold from which quartiles can be determined for a score ranking system (see chapter 6). The aggregation of these scores for the reference condition functions as the basis for biocriteria.

An example of the second approach is the hierarchical decision-making technique used by Maine. It begins with statistical models (linear discriminant analysis) to make an initial prediction of the classification of an unknown sample by comparing it to characteristics of each class identified in the baseline database (Davies et al. 1991). The output from analysis by the primary statistical model is a list of probabilities of membership for each of four classes (A, B, C, and nonattainment of Class C). Subsequent models are designed to distinguish between a given class and any higher classes as one group, and any lower classes as a second group (Fig. 7-1).

An important consideration is how conservative or protective the agency wants to be. The more conservative the resource agency, the more likely it is that the criterion will be set at the upper end of the condition spectrum. The more liberal the agency is in assessing impairment and maintaining the aquatic life use, the more liberal the criterion will be. Examining the variance structure in a manner similar to that described earlier helps validate the extent to which particular biocriteria apply. If there is little biotic variation evident among the initial regions, or if their differences can be associated with management practices that can be altered, it seems wise to combine those regions to adhere to the same biocriteria.

Some site-specific rules of exception to regional biocriteria are necessary to accommodate natural limitations.

In the absence of a strong case for subregional biocriteria, it is probably better to overprotect by setting high biocriteria over broad regions than to underprotect by using too low a threshold. Procedures can then be developed that allow for both regional and subregional deviations from the broadly established biocriteria if, and only if, the deviation is justified by natural anomalies.

In these instances, some site-specific rules of exception to regional biocriteria are necessary to accommodate natural limitations. For example, certain natural channel configurations, such as those flowing through bedrock or those that have natural barriers to dispersal, do not offer the habitat diversity of other channel configurations. They cannot, therefore, support the richness

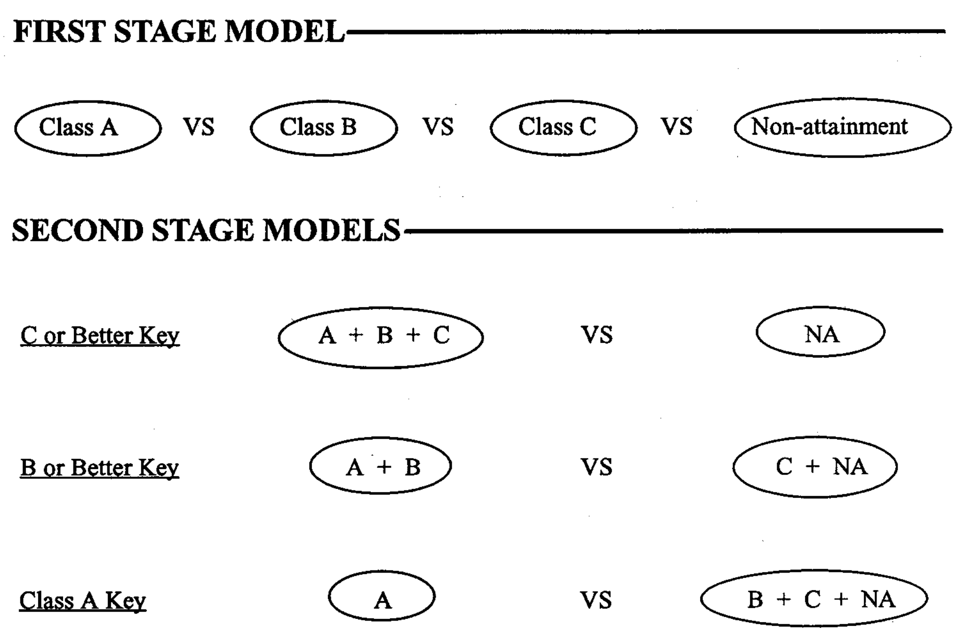

Figure 7-1.—Hierarchy of statistical models used in Maine's biological criteria program (taken from Davies et al. 1993).

The objective in setting biocriteria is to improve the quality of our water resources. Therefore, criteria must not be predicated on accepting the existing, degraded conditions as a matter of course.

In significantly impaired areas, the lowest potentially acceptable criterion is the "best, most natural condition remaining in the region."

and diversity of other nearby channel types. Other natural restrictions to achievement can also be identified, but care must be taken that culturally degraded conditions are not included as evidence for regional biocriteria modification.

Biocriteria for Significantly Impacted Areas

A key element in setting biological criteria is to avoid establishing unduly low thresholds. The objective is to improve the quality of our water resources; therefore, criteria must not be predicated on accepting the existing degraded conditions as a matter of course. In significantly impaired areas, the lowest potentially acceptable criterion is the "best, most natural condition remaining in the region" as defined by a review of the classification data. The upper range for such criteria should be the best condition that is physically and economically achievable by restoration management activities.

This determination is best made by an objective and balanced panel of experts representing the research community, industry, and local, state, and federal water resources specialists using information developed from current and historical data. The actual selection, that is, the point within this range that will become the criterion, should also be established by this panel. This criterion is expected to move upward periodically as management efforts improve the resource condition. A review process should be keyed to the periodic calibrations of regional reference conditions conducted by the states.

There may be no acceptable reference sites in significantly impaired regions. In these areas, an ecological model based on (1) neighboring site classes, (2) expert consensus, and (3) composite of "best" ecological information, may be used (Fig. 3-1). The resultant biocriteria may be an interim or hypothetical expectation that will improve with restoration and mitigation.

Selecting the Assessment Site

Assessment sites should be established to evaluate the effects of human activities on water resources. Potential assessment sites can be identified from land use and topographic maps; specific information can be provided by state and county personnel familiar with the areas. Such sites are generally selected to reflect the influence of known or suspected point and nonpoint source pollution loadings. Final selection should be made only after field reconnaissance by qualified staff at the site verifies that the documented conditions are accurate.

For discrimination of sources and causes of impairment, an agency may need to establish an "impaired" sites database with similar impairments to compare with information at aquatic community test sites. These comparisons can be made using biological response signatures (Yoder, 1991). A *biological response signature* is a unique combination of biological attributes that identify individual impact types or the cumulative impacts of several related human influences. For best results, this process requires the development of an extensive database.

■ **National Pollutant Discharge Elimination System (NPDES) Permit Requests or Renewals.** Public or private wastewater treatment plant administrators and industrial dischargers must apply for NPDES permits. If the number of test sites prohibits annual or more frequent monitoring surveys, a percentage can be surveyed on a rotational basis each year. Priorities can be assigned to permits requiring the earliest renewal or permit award and those in the same geographical area or watershed. Other permitting programs include hazardous waste site regulation, Clean Water Act, section 404/401, dredge and fill certification programs, and construction sites.

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■ **Locations of Concentrated Commercial or Industrial Discharges.** In addition to specified permit locations, states may find it appropriate to establish nonspecific monitoring stations along the stream system. These stations can be particularly helpful if located between clusters of commercial, industrial, or municipal operations to help distinguish among potential sources and between groups of users. In addition, the use of nonspecific monitoring stations will help to distinguish discharge effects from preexisting upstream impacts, a distinction particularly helpful given the typical sequential placement of textile or lumber mill operations along small river courses.

■ **Agricultural Concentrations.** Areas of intensive and extensive farming activities are appropriate for the placement of test sites because they can help isolate potential nonpoint source loadings or impairments. Such areas of interest include croplands, rangelands, clearcuts, feedlots, animal holding facilities, manure holding systems, convergent field drainings, contiguous farms, and fertilizer, feed, and pesticide storage facilities. County agricultural extension agents can help determine site placements. They can also identify high risk localities and farms engaged in cooperative conservation programs and suggest appropriate remedial land use practices and programs if and when problems are identified.

■ **Urban Centers.** The locations of shopping centers, commercial districts, and residential areas that include stormwater runoff concentrations are a source of impact to watersheds. Also of interest are urban developments in riparian zones (areas bordering waterbodies), whether or not they contain wastewater treatment plants. On-site wastewater disposal is common in older communities on small lots concentrated near the waterway. The potential septic system problem in these communities can be compounded by an overburdened stormwater drainage network.

■ **Transportation Services.** Vehicle and other traffic modes also affect water resources: major highway interchanges near a watercourse; streams paralleled by extensive, heavily traveled roads or railroads; heavily traveled bridge or overpass systems; pipelines; and maintenance facilities including stockpiles of deicing salt located near a stream system. Airports and railroad or truck marshaling yards may also generate surface runoff problems for nearby stream systems.

■ **Mining and Logging Activities.** Any area affected by cumulative and sequential mining activities and effects including road construction, drilling wells, logging prior to mineral extraction, and acid mine drainage should be evaluated for test site placement. The basis for such decisions will be state mining permit records and associated maps because the areas of potential impact, especially from subsurface mining and abandoned mines, may not be self-evident.

■ **Forest Management Activities.** Any areas affected by logging and sawmill activities should be evaluated for test site placement. Instability created by road construction in timber areas is especially damaging to water resources. Effective forestry best management practices (BMPs) will be important influences in these areas. Protection of these areas is critical because many of the representative reference sites will be located in forested lands. Federal and state foresters need to interact with state water quality agencies for identification of sensitive areas.

■ **Disruptive Land Use Activities.** This category will include a variety of planned or existing construction projects: landfills; channelization or other in-stream projects such as dams and flood control structures, fish hatcheries, or aquaculture. Any of these activities on a significant scale or near streams should be monitored and evaluated. If advance notice of these activities is provided, states should establish both spatial and temporal monitoring before, during, and after the activities for biological assessments.

■ **Land Use Activities in Unsurveyed or Remote Areas.** This category includes regions not previously surveyed for which no preexisting information would be available in the event of a spill or major hydrological calamity and remote sites for which development is planned in the near or distant future. Long-term antecedent biological information should be a component in new development planning.

Evaluating the Assessment Site

Assessment sites are points or reaches on a stream at which disturbance is suspected or from which information about the location's relative quality is desired.

Statistically evaluating the test site(s) against the reference condition to assess the extent and degree of impairment is the focus of another document (Reckhow, in review); however, the basic question is this: What evidence do we have that indicates impairment (or absence of impairment)? If the assessment is based on a reference condition determined from a composite of sites, the manager's confidence in the judgment is improved over that from use of a single reference site — notwithstanding that some level of precision may be lost (see Chapter 3).

The simultaneous comparison of an assessment site to a site-specific reference condition is an alternative that is generally undertaken as an upstream/downstream or paired watershed approach. Presumably the site-specific reference condition represents the best attainable condition of the assessment site(s). In this approach, the percent-of-reference may be the most appropriate criterion from which to assess impairment. States that have limited resources may wish to implement this approach as an interim until a larger database is developed. The assessment of sites follows the same guidelines whether reference data are site-specific or regional (Table 7-1).

Assessment sites are points or reaches on a stream at which disturbance is suspected or from which information about the location's relative quality is desired. In selecting assessment sites, the latitude of selection compared to the choice of reference sites may be considerably reduced. If the area is suspect, it must be investigated regardless of its stream charac-

Table 7-1.—Sequential process for assessment of test sites and determination of their relationship to established biocriteria. Refer to Chapter 6 for an explanation of biocriteria establishment.

ASSESSMENT PROCESS	
Step 1.	Determine Class • same classification scheme as for reference sites
Step 2.	Survey Assessment Sites • biota and physical habitat
Step 3.	Calculate Metrics • convert raw data to metric values
Step 4.	Aggregate Metrics to Form Indices • use scoring rules established for metrics • sum normalized metric values
Step 5.	Compare to Reference (Biocriteria) • use established regional biocriteria for assessment
Step 6.	Statement of Condition • characterize existence and extent of impairment • diagnostics as to stressors

teristics or channel configuration. Thus, regionalized reference conditions, while necessary for criteria development, may not always be sufficient to serve as a foundation for expecting a specific biological condition. The investigator facing a potentially contentious situation may find it prudent to augment the regional reference data with results of locally matched reference sites, such as upstream sites or sites in similar, nearby streams.

The assessment process is essentially a replication of the procedure described earlier to develop multiple metrics (see Chapter 6 and Fig. 6-2). Note, however, that the move from the development of metrics and indices to their use in the assessment process leads directly to the development and implementation of biocriteria. The assessment process, summarized in Table 7-1 and illustrated in Figure 7-2, is described as follows:

Step 1 — Classification of Assessment Sites. Sites selected for assessment are assigned to the appropriate classification derived from the initial reference classification scheme. The assessment site is classified according to the stream class designations, not the nature of a suspected land use or point-source discharge impact. In other words, similar receiving waters should be in the same classification whether or not there are similar discharges to those waters.

Step 2 — Biosurvey. Stream or small river biological communities and habitat characteristics should be measured using the same techniques and equipment as were used at designated reference site(s). It will also be necessary to gather data during the same time frame. This schedule may not coincide with a predetermined indexing period. For example, if a construction site is scheduled to open on a particular date or if a critical period of operation is approaching, both the test and reference site(s) will have to be surveyed accordingly.

Step 3 — Calculate Metrics. Many of the intermediate steps used in the criteria development process become unnecessary at this point. Investigators can simply enter the appropriate raw data from the refer-

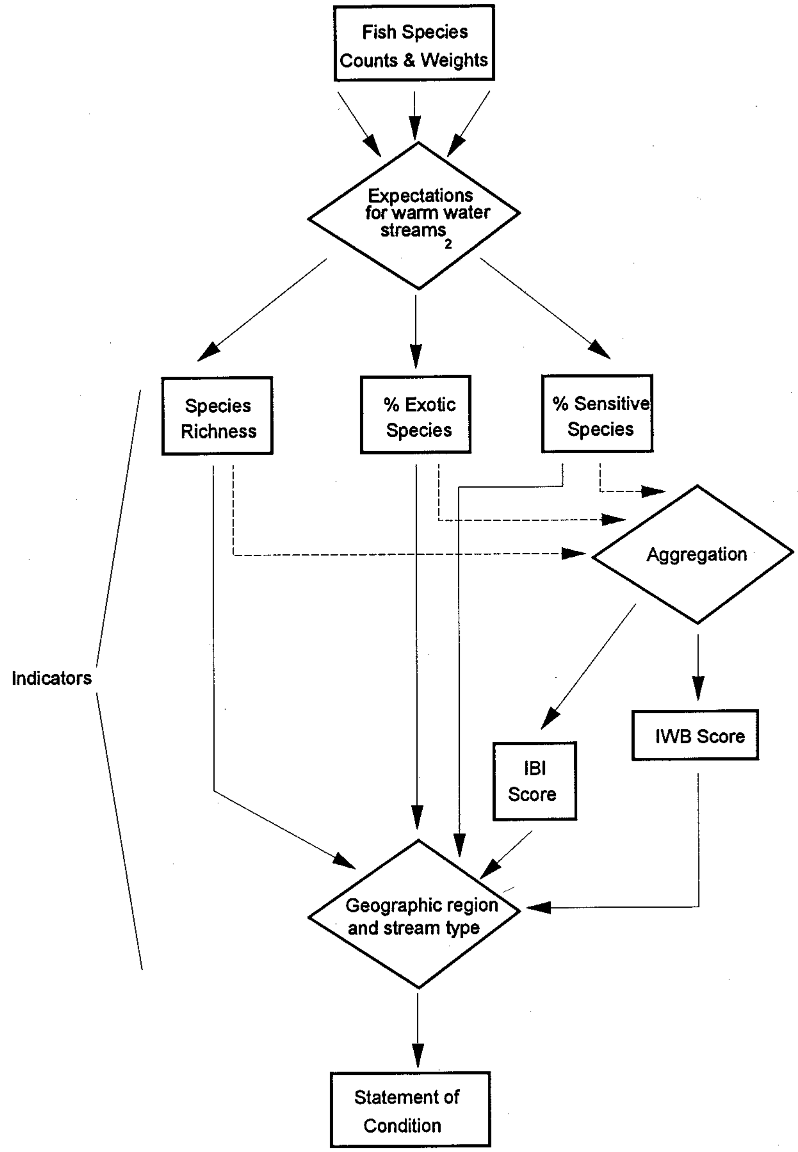

Figure 7-2.—The process for proceeding from measurements of fish assemblage to indicators such as the Index of Biotic Integrity (IBI) or Index of Well Being (IWB) — as used to develop criteria and apply those criteria to streams (modified from Paulsen et al. 1991).

ence and test sites into a preselected format to generate current metrics. In all cases, the integrity of the raw data should be presumed for support and as additional information for more definitive assessment.

Step 4 — Calculate Indices. Where indicated, these metrics are similarly summarized in indices of relative biological condition and habitat description. Some states do not use indices but evaluate the information from the individual metrics as independent measures of biological condition.

Step 5 — Compare to Appropriate Biological Criteria. The biological data from the site under assessment are compared to established criteria to ascertain the status. Both the indices (aggregation of metrics) and the individual metrics are evaluated as part of the assessment. All available information must be used to confirm the status of the biological condition and to diagnose the cause and effect relationship if impairment is detected.

Step 6 — Statement of Condition. At this point, the assessment sites are evaluated to determine whether they do or do not meet the criteria. The sites can also be placed in priority order using the details of this evaluation to support management plans and resource allocations. Further refinement of the data collected and additional investigations can help determine cause and effect relationships among the stresses identified by this process. Such information will be essential to successful remedial management.

Overview of Selected State Biocriteria Programs

■ **Maine.** In 1986, the State of Maine enacted legislation that mandated an objective "to restore and maintain the chemical, physical, and biological integrity" of Maine waters. In addition, a legislative water quality classification system was established to manage and protect the quality of Maine waters. The classification system established minimum standards for designated uses of water and related characteristics of those uses (Table 7-2). Within each use-attainability class, the minimum condition of aquatic life necessary to attain that class is described.

The descriptions or narrative standards in this legislation range from statements such as "Change in community composition may occur" (Class C) to "Aquatic life as naturally occurs" (Class A and AA). The designated use classes were recombined into four biologically discernible classes (Table 7-2): Classes A and AA were combined, and a fourth class, nonattainment of Class C, was added.

The Maine Department of Environmental Protection has assessed a large, standardized macroinvertebrate community database from samples taken above and below all major point-source discharges, as well as samples from relatively undisturbed areas. Maine used this database as a calibration dataset to develop discriminant functions for classifying sites among the four analytical classes.

The calibration data set consisted of the general level of abundances from 145 rock basket samples collected from first to seventh order streams throughout Maine, and covering a wide range of relatively unimpacted and impacted streams. General abundances were reduced to approximately 30 quantitative metrics.

The calibration data set was given to five stream biologists to assign the 145 sites to the four classes (A, B, C, and NA) using professional judgment. The biologists used only the biological data; they did not see locations, names, habitat, or site chemistry. Disagreements on class assignments were resolved in conference.

The resultant metrics and class assignments were then used to develop linear discriminant models to predict class membership of unknown assessment sites. Two stages of discriminant models were developed from the calibration data set: the first stage estimates the probability that a site belongs to one of the four classes (A, B, C, or NA); the second stage esti-

Table 7-2.—Maine's water quality classification system for rivers and streams, with associated biological standards (taken from Davies et al. 1993).

AQUATIC LIFE USE CLASS	MANAGEMENT	BIOLOGICAL STANDARD	DISCRIMINANT CLASS
AA	High quality water for recreation and ecological interests. No discharges or impoundments permitted.	Habitat natural and free flowing. Aquatic life as naturally occurs.	A
A	High quality water with limited human interference. Discharges restricted to noncontact process water or highly treated wastewater equal to or better than the receiving water. Impoundments allowed.	Habitat natural. Aquatic life as naturally occurs.	A and AA are indistinguishable because biota are "as naturally occurs."
B	Good quality water. Discharge of well treated effluent with ample dilution permitted.	Habitat unimpaired. Ambient water quality sufficient to support life stages of all indigenous aquatic species. Only nondetrimental changes in community composition allowed.	B
C	Lowest water quality. Maintains the interim goals of the Federal Water Quality Act (fishable/swimmable). Discharge of well-treated effluent permitted.	Ambient water quality sufficient to support life stages of all indigenous fish species. Change in community composition may occur but structure and function of the community must be maintained.	C
NA			Not attaining Class C

mates two-way probabilities that a site belongs to higher or lower classes (i.e., A, B, C. *vs.* NA; A, B, *vs.* C, NA; and A *vs.* B, C, NA). Each model uses different metrics.

In operational assessment, sites are evaluated with the two-step hierarchical models. The first stage linear discriminant model is applied to estimate the probability of membership of sites into one of four classes (A, B, C, or NA). Second, the series of two-way models are applied to distinguish the membership between a given class and any higher classes, as one group (Fig. 7-1). Monitored test sites are then assigned to one of the four classes based on the probability of that result, and uncertainty is expressed for intermediate sites. The classification can be the basis for management action if a site has gone down in class, or for reclassification to a higher class if the site has improved.

Maine biocriteria thus establish a direct relationship between management objectives (the three aquatic life use classes and nonattainment) and biological measurements. The relationship is immediately viable for management and enforcement as long as the aquatic life use classes remain the same. If the classes are redefined, a complete reassignment of streams and a review of the calibration procedure will be necessary.

■ **North Carolina.** The North Carolina Department of Environment, Health and Natural Resources, Division of Environmental Management, Water Quality Section has written Standard Operating Procedures for the collection of biological data and the bioclassification of each station sampled. Biological criteria have been included in the North Carolina water quality standards as written narratives. Narrative standards have been in place since 1983. They support the use of biological assessments in point and nonpoint source evaluation, and help identify and protect the best uses of North Carolina waters. High Quality Waters, Outstanding Resource Waters and Nutrient Sensitive Waters are assessed using biocriteria.

Phytoplankton, aquatic macrophytes, benthic macroinvertebrates, and fish are routinely collected as part of North Carolina's biosurvey effort. Only the macroinvertebrate biosurvey data and the associated bioclassification system are summarized here.

Macroinvertebrates are sampled qualitatively by one of two methods: a Standard Qualitative Method or the Ephemeroptera, Plecoptera, and Trichoptera (EPT) Survey Method. When following the Standard Qualitative Method, two kick net samples from cobble substrate, three dip-net samples (sweeps) from vegetation and shore zones, one leaf pack sample, two fine-mesh rock and/or log wash samples, one fine-mesh sand sample, and visual inspection samples are taken.

The EPT survey method focuses on qualitative collection of Ephemeroptera, Plecoptera, and Trichoptera, by collecting one kick sample, one sweep sample, one leaf-pack sample and visual collections. With both methods, invertebrates are sorted in the field using forceps and white plastic trays, and preserved in glass vials containing 5 percent ethanol. Organisms are sorted in approximate proportion to their relative abundance.

Currently, site-specific reference conditions are typically used when conducting surveys. However, where site-specific reference sites are not available, ecoregional reference conditions are used to define unimpaired conditions. North Carolina is developing ecoregional reference conditions based on the available land use information. The three major ecoregions identified in North Carolina are Mountain, Piedmont, and Coastal Plain.

Specific macroinvertebrate metrics, including taxonomic richness, biotic indices, an Indicator Assemblage Index (IAI), diversity indices (Shannon's Index), and the Index of Community Integrity (ICI) are used to rate sites as poor, fair, good/fair, good, and excellent. The ratings are conducted in addition to the narrative descriptions for biocriteria. These metrics are used as independent measures rather than aggregated into an overall index.

Bioclassification criteria for the Mountain, Piedmont, and Coastal Plain ecoregions in North Carolina have been developed for EPT taxa richness values. This community metric has been developed using both the Standard Qualitative Method and the EPT Survey Method. The bioclassification ratings for the number of EPT taxa in each ecoregion for both the Standard Qualitative Method and the EPT method are summarized in Table 7-3. Note that the rating system has been developed solely on summer (June-September) collections. Samples collected in other seasons, therefore, must be seasonally corrected before a bioclassification can be assigned.

The North Carolina classification system was developed for chemical impact assessment and does not address sedimentation or other habitat alteration effects. A special bioclassification rating has also been developed

Table 7-3.—Bioclassification criteria scores for EPT taxa richness values for three North Carolina ecoregions based on two sampling methods.

	STANDARD QUALITATIVE METHOD		
BIOCLASSIFICATION	**MOUNTAIN**	**PIEDMONT**	**COASTAL PLAIN**
Excellent	>41	>31	>27
Good	32-41	24-31	21-27
Fair	12-21	8-15	7-13
Poor	0-11	0-7	0-6
	EPT QUALITATIVE METHOD		
BIOCLASSIFICATION	**MOUNTAIN**	**PIEDMONT**	**COASTAL PLAIN**
Excellent	>35	>27	>23
Good	28-35	21-27	18-23
Good-Fair	19-27	14-20	12-17
Fair	11-18	7-13	6-11
Poor	0-10	0-6	0-5

for small, high quality mountain streams which naturally exhibit a reduced macroinvertebrate taxa number. Streams possessing these particular characteristics, having EPT taxa of ≥ 29 (Standard Qualitative Method) or ≥ 26 (EPT Survey Method) are considered excellent.

■ **Ohio.** Ohio's biological criteria program was developed for complete integration with state water quality standard regulations. As such, biocriteria in Ohio are fully integrated with typical water quality measures, and address three key strategic goals:

- The protection of aquatic life in all Ohio waterways capable of supporting aquatic life is an immediate goal of the Ohio EPA to be accomplished, wherever possible, through a "systems" (biological community response) approach.
- Short- and long-range goals must be established for the control of toxic substances in Ohio's surface waters.
- The protection of human health through the assurance of a "safe" level of exposure to toxic substances in water and fish is an immediate goal of the Ohio EPA.

To accomplish these goals, the Ohio EPA program combines biocriteria, effluent toxicity, and water chemistry. This integrated approach has significantly increased Ohio EPA's ability to detect degradation, particularly in streams receiving point and nonpoint sources and both toxic and conventional pollutants.

The Ohio EPA has employed the concept of tiered aquatic life uses in the Ohio Water Quality Standards (WQS) since 1978. Aquatic life uses in Ohio include the Warmwater Habitat (WWH), Exceptional Warmwater Habitat (EWH), Cold-water Habitat (CWH), Seasonal Salmonid Habitat (SSH), Modified Warmwater Habitat (three subcategories: channel-modified, MWH-C; affected by mines, MWH-A; and impounded, MWH-I), Limited Resource Water (LRW) (Ohio EPA 1992). Each of these use designations are defined in the Ohio WQS.